inconvenience, and using their hands to force the ends of large earthworms into their mouths. They could be made to take meat and even carrion held on a needle before them. In this way the captive frogs were made much more fat and larger than those of the same ages outside.

Such overfed creatures developed a second period of sexual excitement in midsummer, but this led merely to certain males grasping the females for a short period.

Observations made in the neighborhood of Zofingen, Switzerland, and upon a frog not found here, may have no direct bearing upon the life history of our own frogs, but they indicate lines for imitation. With increasing interest in aquaria and gardens, both botanical and zoölogical, we may hope for more natural history work of this kind, and for the filling up of immense gaps in our knowledge concerning the length of life and rate of growth of animals.

E. A. A.

Psychical Qualities of Ants and Bees.[1] — The question as to whether or not we may ascribe psychical qualities to ants and bees is discussed by Albrecht Bethe in a recent issue of *Pflüger's Archiv.*

In his introduction the author points out the danger of an investigator's personality being read into the subject investigated, and also danger of the use of such words as carry with them meanings not warranted by the facts; men see, but all we know about bees is that they are influenced by light, and it would be unscientific to say they do anything so highly psychical as seeing until it is proved. It is absolutely impossible to find words which are always consistent with this idea, but the endeavor has been made to do so as far as possible.

The polymorphic colonies of bees and ants are pointed out as giving direct evidence against the Lamarckian principle of the inheritance of acquired characters. This polymorphism, Bethe believes, is completely explained through congenital diversity and natural selection, as is true also for all purposeful reflexes.

It is well in reading the paper to bear in mind the author's distinction between reflexes and instincts. "Only those actions can be designated instinctive in which an animal, which can be proved to possess psychical qualities, follows an inherited impulse without a

[1] Albrecht Bethe, Dürfen wir den Ameisen und Bienen psychische Qualitäten zuschreiben? *Archiv f. d. Ges. Phys.*, vol. lxx, Pts. i, ii, pp. 15–100, January, 1898.

previous process of learning, in which the action is not purely reflex, but is eventually regulated through psychical processes"; "sexual intercourse is instinctive in man, but is a reflex in beetles. A silk-worm spins its cocoon reflexly, but a bird builds its nest instinctively. Instincts are neither wholly reflex nor wholly psychic."

Individual diversity extends farther than is generally supposed; even the odors given off by individuals are characteristic, since through them bloodhounds are able to follow one trail unerringly.

The first one of the two main divisions of the paper is devoted to a research on ants, and the first question asked is:

"Do ants of one colony recognize each other?"

From the fact that an ant, if placed on a nest (not its own) of either the same or a different species, will be seized and often killed, it has been concluded that they know each other personally and distinguish between strangers and their own number, although some nests contain thousands of individuals.

Lubbock investigated this subject and found that:

1. After a separation of almost two years, individuals of *Fomica fusca* were received in a friendly manner when placed back on their own nest.

2. Pupæ, separated from their nest but cared for by workers from it, were received in a friendly manner without exception if placed back when grown.

3. If pupæ were cared for by workers of another nest, it was different. Out of forty-four placed on their own nest, seven were attacked and thirty-seven received. Of fifteen placed on the foster worker's nest, all were attacked.

4. An egg-laying queen was taken from her nest, and her subsequent brood when grown was not seized when placed on the nest. These results led Lubbock to believe that there is no personal recognition among ants of one nest; and from the fact that chloroformed ants were received by their own fellows but seized by individuals of a strange nest, he concluded that reception or rejection did not depend upon any sign or word, but what was at the bottom of the matter he did not understand.

Romanes thought their methods of distinguishing each other were not capable of being understood by us, but that it was, through some kind of psychical process, a species of memory.

McCook, observing that after an ant had fallen into water it was attacked when coming home, concluded that through the bath the ant had lost its peculiar odor, hence was no longer recognized.

Forel found that ants of different nests could be brought together without one seizing the other, provided the antennæ be first removed. He held that the sense of smell was located in the antennæ, and that it is through this sense that ants of the same nest are recognized.

But unless it had been shown that each ant learns in its individual life to answer the smell of its own nest fellows in a friendly, and that of strange ants in an unfriendly, manner, and that it does not do this *ab-ovo*, it is not proved that we are dealing with "knowledge" or "thought."

An ant smeared with an extract of the bodies of its own nest fellows is received when placed on its own nest, but seized if smeared with an extract of strange ants. This was tried in several cases and held true in each.

An ant if first bathed in 30% alcohol, then with water, then smeared with the extract of another species, will be received by the colony from which the extract is made. From the fact that the strange ant may be many times larger than those among which it is introduced and of a different color, it is proved that *form* or *color* plays no rôle, but as the presence of a strange ant disturbs them when several millimeters away, it would appear that a volatile chemical material is concerned in the different reaction of ants toward their fellows or toward strangers. If the ant be washed with 30% alcohol and water, and as soon as dry returned to the colony, it will be seized, but if kept away twenty-four hours and then returned, the colony will receive it. From this and Lubbock's experiments it is shown that this volatile material, which is called "Neststoff," is alike for individuals of the same nest, and every nest has its characteristic "nest material," which is produced by each individual.

Young ants, of a *Lasius nigra* nest, which had never met a stranger, were allowed to mature and harden in a box, then some were placed on a nest of Tetramoria, which were thrown into the greatest unquiet; some were placed on their own nest, where they ran quietly among their nest fellows. A few Tetramoria were placed in the box with the remaining ants, and the Tetramoria were at once attacked. Nothing here had been learned but that the different reactions toward like and unlike "nest materials" are inherited. Like material (that produced by ants of the same nest) constitutes no stimulus, but unlike "nest material" calls forth a reflex of either fighting or fleeing, depending on the amount present.

Ants, if confined in a gauze box on their own nest, will not be noticed but allowed to starve. Ants of another nest placed in the

same box will call out the fighting reflex of dozens, which soon surround it, endeavoring to get in. The relative amounts of the two "nest materials" seem to determine the reflex. The actions usually explained through "love," "compassion," or "hate" are better explained on purely physiological grounds.

In pupæ the "nest material" is not yet differentiated, for all pupæ will be eagerly accepted by all ants. As the pupæ grow, their "nest material" mixes with that of the foster colony and the whole is modified. A colony of more than one species is thus formed, examples of which are found in slave-making ants. The slaves of a nest will not be received if placed in the nest from which taken. They do not know their masters, nor do the masters know the slaves. They have become one colony through the mixing of their "nest materials."

From the foregoing it appears that the different reactions of ants toward individuals of their own and different nests depend on reflexes.

The next question that the author considers is:

"How do ants find their way?"

It is generally thought that ants know the region about the nest, and orient themselves when going about by familiar objects, either through sight or smell. They travel on paths, and when off the path are lost until it is regained. Some sugar was placed on a blackened paper in front of a nest. The first foraging ant did not find the sugar; the second ant, after making many curves, zigzags, and loops, found the sugar, took a grain and retraced its steps, but cut off the loops. Before it had reached home a third ant had come to the place on the paper where No. 2 had left it, followed its track to the sugar, and returned the same way; and all ants which came near this path followed, each straightening it, however, by an antenna's length, until in an hour or two there was a straight path between the nest and the sugar. None followed the unsuccessful trail. It would appear from this that not only is a track left which may serve as a guide to other ants, but which is of such a nature as to indicate the outcome of the expedition. The paths were followed as well when covered with black paper tunnels as if left well lighted, but a strip of paper 5–10 mm. wide laid flat across a path would bother the ants greatly. They would stop on reaching the paper, become very unquiet, several would collect on both sides, but none would cross over; some would turn and go back, some try to crawl under the paper. Something is deposited on the path which guides them, the volatile nature of which is shown by the fact that if the strip of paper is allowed to remain

until the path is well established across it and then removed, the space from which it was taken becomes as great a hindrance as the paper when first laid down. The drawing of the finger across a path leading over a glass plate will cause the same result as the paper strip. In the first case the guiding material is covered up, in the second it has passed off naturally, while in the last it has been wiped away.

Loaded ants, even if picked up, rotated, and placed on the path backward, always go toward the nest. A path was led across a board, a section of which could be reversed, thus making a part of the path lead in the opposite direction from which laid down. When reversed, the next ant on coming to the section from either direction would stop, flourish its antennæ over the path, run first to one side and then the other, but would not proceed. If the section was not reversed until the ant was on it, the ant would continue on its way across the section, but on coming to the place where the section ended, instead of going on it would act as described above. These and other similar experiments leave little doubt that there is a polarization of the guiding material; but to say it is polarized does not explain all phenomena. Unless the ants walked home backward or deposited the material backward while coming home, there would be nothing present to indicate the direction of the nest. One experiment showed, however, that outgoing ants follow the paths of incoming ants with difficulty, and *vice versa*. This indicates the existence of two different guiding materials in the same path, one an incoming guiding material, the other deposited by outgoing ants.

Lubbock thought that he had proved that ants communicate with one another, but Bethe uses one of Lubbock's own experiments to show that it proves nothing. If a handful of pupæ placed on a piece of paper near the nest be found by an ant, soon numbers of ants will be carrying the pupæ home; but if an ant be carried to the pupæ and when it has taken one, it be aided to find its way home and so on for several trips, using the same ant each time, no other ants ever find the pupæ. In the latter case no path is laid down *to* the pupæ, hence there is nothing to guide the ants to them, while in the former experiment they had a path to guide them. All of Bethe's experiments to ascertain the presence of any communication between ants could as well be explained through simple physiological stimuli as through intelligence.

Several experiments, calculated to call out the intelligent action of ants, should they possess such even in the most meager degree, were carried on, but all with negative results.

The second half of the paper is devoted to a research on bees. Do bees of one hive recognize one another?

Bethe finds that they, like ants, do not know individuals either by sight or smell, but that, *ab-ovo*, they react in a friendly manner toward their own colony "nest material," and in an unfriendly manner toward a "nest material" of bees of other hives. As with ants, two "nest materials" may be so mixed as to become one, as is shown by the method necessary in introducing a new queen into a queenless colony. If unprotected she is at once killed. If, however, she is put among them for a few days, protected by a gauze box, and then liberated, she is received. At first her "nest material" calls out the fighting reflex of the hive, but given time the "nest materials" of both mix and cease to afford any adverse stimulus. That the difference in the "nest materials" of two hives is produced by congenital diversity is shown by the following.

A hive was divided, half the grubs of the old being given to the new hive. In a few days, when these young bees had come out, some were taken from the old hive to the new, and were treated as belonging to the new hive. For two or three weeks bees of one hive could be placed in the other and be well received, but after this time the brood of the new queen began to come out. One of these new bees introduced into the old hive would be killed, and bees from the old hive would be attacked by the new brood of the new hive. Old bees of the new hive if isolated twenty-four hours were still received by the old hive, but after three weeks longer no more mixing of the two hives could be effected. The "nest material" from the new queen had become strong enough to modify that of the whole hive.

How do bees find their way?

They could not leave a material in the air, as is left by ants on their paths, which could guide them to and from the hive, but since a male moth has been known to locate a female several miles distant, it seemed possible that still a volatile chemical material might be the agent which guides bees. A tunnel of paper placed over the entrance to the hive caused a great change in the actions of the bees; few crossed over the paper either in or out, but collected at the edge, both on the inside and outside of the tunnel, and buzzed. When it was removed there was a gush of bees, both entering and leaving the hive. A bridge of paper over the entrance caused no such disturbance, since the entrance board was left free, on which there was a material which guided the crawling bees.

If *flying* bees are guided by the "nest material" which is radiating

from the hive, then turning the hive 90° should have had no effect; but it did. The bees returned to the side where the entrance was before the turning. Thinking that the rapid turning might not have been followed by the dense cloud of "nest material" which exists immediately before the entrance, a hive was mounted on a horizontal wheel, and the whole on a truck, so that the hive could not only be turned slowly, but moved from one place to another.

When a revolution of 90° was made in fifteen minutes, the bees went in well until the 30° point was reached, after which fewer and fewer went in, until at 90°, none entered the hive at all. When twenty minutes were required in turning the hive 90°, the bees went directly in until the 45° point; from this position until the 135° point was reached the stoppage of the bees increased more and more until no bees went in at the latter position.

Reducing the rate of rotation to 90° in forty-five minutes did not produce any different results from the last experiment. As the hive would approach the 180° point, the path on which the bees arrived would swing back to its old position, thus bringing the bees to the back of the hive.

If the hive was drawn back 50 centimeters from its usual position, the bees returned to the place where the entrance was, and, circling about, some would find the entrance. If drawn back 2 meters no bees found the hive, but circled about its old position in hundreds, going into a box if placed there with a hole where the hive entrance had been.

A chemical "nest material" aids somewhat in entering the hive, but does not play the chief rôle in guiding flying bees. Whatever it is seems to guide them not to the hive but to a point in space where it was when left by the bees.

To ascertain if memory pictures have any part in this, a hive was masked so that even a man would not have recognized either it or its surroundings, but so long as neither red nor white was used, no effect was noticed on the bees. These two colors, however, always seemed to disquiet them, causing a collecting, probably through their dazzling effect. This shows that no memory picture of the hive is retained, and to ascertain whether they fly through memory pictures of the region about the hive, the following experiments were made, in which the city near the Institute, in which few flowers bloom and in which a bee is seldom seen, is assumed to be an unknown region, while the meadows around the Institute are assumed to be known to the bees. In each instance eight marked bees were taken 350 meters

from the hive on quiet sunny days and allowed to fly, the hive entrance being watched 12 minutes, with the following results:

Bees from Meadow.	Bees from City.
1.) Used 2⅔ minutes in returning.	1.) Used 1½ minutes in returning.
2.) " 4½ " " "	2–4.) " 2¼ " " "
No more returned during 12 minutes.	5.) " 2¾ " " "
	6.) " 3½ " " "
	Two did not return in 10 minutes.

Greater distances were employed in two other experiments, as follows:

Eight bees carried 400 m. Entrance observed 10 minutes.

Bees from Meadow.	Bees from City.
1.) Used 4½ minutes in returning.	1.) Used 5 minutes in returning.
2, 3.) " 5 " " "	2.) " 7 " " "
4, 5.) " 6 " " "	3, 4.) " 10 " " "
6–8.) " ? " " "	5–8.) " ? " " "

Ten bees carried 650 m. Entrance observed 12 minutes.

1.) Used 5 minutes in returning.	1.) Used 4¾ minutes in returning.
2.) " 5½ " " "	2, 3.) " 5¼ " " "
3.) " 7 " " "	4.) " 7½ " " "
4.) " 9½ " " "	5.) " 9 " " "
5.) " 11 " " "	6, 7.) " 10½ " " "
6–9.) " ? " " "	8.) " ? " " "
10.) Did not fly from box.	9, 10.) Did not fly from box.

The bees did not see the Institute, but in nearly every case started in the right direction before flying up over the tops of the houses which were between them and the hive. Memory pictures do not seem to aid them on their homeward journey, but some unknown force, which from the following experiments seems to guide them not to the hive but to a point in space which may or may not be the one in which the hive stands or stood.

Of a number of bees carried in a box a long distance from the hive and liberated, not all returned to the hive, but some, after circling in the air for some seconds, returned to the box, which had been set on a rock before being opened.

These bees were thrown into the air again, and the box removed. This time the bees came to the spot where the box had been.

The bees were again liberated while holding the box in the hand above the ground, then stepping back some distance the bees were observed to come to the space where the box had been and to circle about it some time.

This unknown force does not operate an infinite distance, but is limited to an area the radius of which is about three miles.

In conclusion, then, the author finds nothing in the phenomena exhibited by bees or ants to prove the existence of any psychical quality. They learn nothing, but act mechanically in whatever they do, their complicated reflexes being set off by simple physiological stimuli.

CASWELL GRAVE.

Studies on Hair. — In the last number of the *Jenaische Zeitschrift* (vol. xxxi, p. 605) Dr. Fritz Römer continues his studies on the integument of mammals in an article dealing with the arrangement of the hair on the African rodent *Thryonomys swinderianus*. In an embryo of this species, about sixteen centimeters long, the head, trunk, extremities, and base of the tail seemed covered with rows of small scales. On closer inspection this appearance was found to be due not to scales, but to the arrangement of the hair. The hairs were placed in short, slightly curved rows, each row containing three, five, eight or twelve hairs. While in any row the middle hairs were longer than the lateral ones, no single, large, central hair could be distinguished, as de Meijere has found in the hair groups of so many mammals. Römer explains the rows of hairs in Thryonomys by assuming that they were originally developed on an ancestral form covered with scales, the rows of hairs alternating with the scales, and the scales afterwards disappearing. Since the publication of de Meijere's paper on the hairs of mammals this theory has been gaining ground. Beside these regularly arranged hairs the embryo examined by Römer showed many small, irregularly scattered hair germs which, upon further examination, were shown to give rise to the fine hairs of the thick winter fur, the summer fur consisting almost entirely of the regularly arranged hairs. The summer fur, then, presumably represents a hair arrangement phylogenetically older than the winter fur.

G. H. P.

The Eyes of Amphioxus. — The organs of vision in Amphioxus have been made the subject of careful study by Dr. R. Hesse.[1] They consist of very simple direction eyes, lying close to the central canal of the spinal cord. They occur from the third muscle segment very nearly to the tail. The eyes are not uniformly distributed along the cord, but are arranged in segmental groups, the groups corresponding to the muscle segments and, consequently, alternating on the two

[1] *Tübinger Zoologische Arbeiten*, Bd. ii, No. 9, 1898.